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PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Agronomist in Charge,

Mayaguez, P. R.

# REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

# 1916.

UNDER THE SUPERVISION OF
STATES RELATIONS SERVICE,
Office of Experiment Stations,
U. S. DEPARTMENT OF AGRICULTURE.

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1918.

## PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

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# LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
*Mayaguez, P. R., February 20, 1917.*

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1916.

Respectfully,

D. W. MAY,
*Agronomist in Charge.*

Dr. A. C. TRUE,
*Director States Relations Service,*
*U. S. Department of Agriculture, Washington, D. C.*

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
*Secretary of Agriculture.*

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# REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1916.

## REPORT OF THE AGRONOMIST IN CHARGE.

By D. W. May.

### INTRODUCTION.

A distinct gain in agricultural production in Porto Rico has been made during the year, with increased profits, as most products have been high in price and the yields have been excellent. This has been true especially of food crops, for which an unprecedented demand has been created by international economic conditions. The high prices have stimulated greater skill, more and better cultivation, and the use of larger quantities of fertilizer. Also more land has been brought under the plow than ever before in the history of the island. This is the factor that promises most for the future, for Porto Rico, though densely populated (about 350 persons to the square mile), has only about 20 per cent of its soil under cultivation, in spite of the fact that it has scarcely any land that is wholly unproductive. The real agricultural problems of the island are to find the crops best suited to the various sections, to induce the inhabitants to grow them, and so to watch the demands of the markets as to secure profits commensurate with yields.

### SUGAR CANE.

Sugar continued to be the leading crop, bringing prices during the year which have resulted in large profits. Cane planters for a number of years have studied closely the improved methods of growing cane and have introduced and planted new varieties of seedling canes which are now giving excellent returns.

To induce planters to practice rotation of crops on cane lands is a matter requiring constant attention, as the general custom is to allow such lands to grow up to pasture. The station has been urging the planting of legumes after taking off the last crop. A number of legumes have given good results in rotations with cane, but the velvet bean has proved best. It makes an enormous growth (Pl. I, fig. 1), is well inoculated with nitrogen-storing bacteria, and yields a large quantity of forage, which is very necessary for the herds of work cattle used in cane production. Moreover, the velvet bean is easily planted,

and it is scarcely more expensive to grow this crop than to allow the land to lie fallow.

Another good practice advocated by the station is that of planting beans in the young cane. One of the largest Porto Rican importations is the red bean, which, with rice, is the principal article of diet of the people. Not only is the growing of this crop profitable in itself, but the practice greatly improves the land by storing nitrogen, the fertilizing element most needed by Porto Rican soils. Since the laborer needs the beans for food, and the planter needs nitrogen in his soil, the mutual advantage of permitting the laborers to plant beans wherever possible is evident. A crop of beans may be grown in the young cane at a profit, but the resulting improvement of the soil will repay the owner, though he give the cultivator the entire crop.

## COFFEE.

The coffee industry has lagged throughout the year. Prices have been low, and while other agricultural products, many of which the coffee grower has to buy, have increased in price, his money crop has brought poor returns, and the difficulties of marketing it have been great. Europe was the established market for Port Rican coffee, but the war has not only curtailed shipments to many countries, but has wholly stopped intercourse with others. Increasing quantities, however, have been sent to Cuba, especially of the better grades.

Attempts to sell Port Rican coffee in the States have been continued, but with slight success. It is very hard to reach the consumer in the States with a coffee of standard excellence. The consumer takes what his grocer gives him, usually a blend in case of the better grades, which is generally made up of a large quantity of cheap coffee with the smallest possible quantity of an aromatic sort to give flavor to the whole. Such a mixture will average less in cost than the usual market price of Porto Rican coffee in Europe. The merchant has no sentimental interest in marketing coffee, and it is difficult to reach the consumer without his assistance. Even if a demand for a particular variety is created, the buyer frequently can not get it when he wants it, as the total Porto Rican coffee crop is sufficient to supply only a small fraction of the quantity of coffee consumed by the United States.

Again, the most valuable quality of coffee is its flavor, and a taste for a certain flavor is hard to change. People coming to Porto Rico to live usually do not like the flavor of the coffee; but after drinking it for a while they develop a taste for it, and upon going to a district where another coffee is used they do not care for the new sort.

If people in the States could be induced to return to the old way of buying their coffee green and roasting it as needed, then an excellent coffee like that of Porto Rico would find a market and hold it,

and the consumer would reduce materially the high cost of living as well as obtain a better product, as fresh-roasted coffee is superior to the average blend found on the market. Moreover, green coffee improves with age instead of deteriorating, as the general run of products do. The housewife, however, on account of the scarcity of help, is loath to return to methods requiring extra labor when the grocer or coffee roaster is ready to take work off her hands.

A movement promising better success for the coffee growers is the formation of an association which will arrange to have Porto Rican coffee roasted and packed under its own name and brand and to sell its product through a chain of stores or by agreement with grocers who will give it a thorough trial, the growers carefully safeguarding the quality and freshness at all times.

The condition of the coffee planter is a really serious one. Many of the plantations have grown coffee for half a century, and now the trees are too old and the soil too worn to be productive. The remedy for this condition can not be applied quickly, as it requires time and study. Unproductive lands no longer planted to coffee are denuded of their timber and become washed and sterile. It is impossible to get such lands back into coffee without a long series of rotations.

The station has 200 acres of denuded land which reverted to the government. It is bare except for sparse wire grasses and is wind swept and gullied. In getting this area back into cultivation some years without profit must be faced, as even quick-maturing legumes like beans and peas have not returned the seed, while kafir corn, milo maize, rice, and grasses have failed entirely. Peanuts and velvet beans made returns and some unusual plants like roselle yielded crops. Velvet beans are most promising for starting high lands on the return to fertility, and these, with other legumes and live stock, are the surest means of redeeming such areas.

Diversification is the only hope of most coffee growers. On most of the lands not accessible to good roads, crops for export should be such that they could be shipped easily; that is, they should be neither bulky nor perishable. Such imports as beans, which form a large part of the food of the people, could be grown on the coffee plantations. It is hard, however, for the coffee grower who has been a bonanza farmer to take up a small crop, even if it is profitable. Although red beans retail as high as 18 cents a pound and are brought from countries as far away as Manchuria, their production appeals to the coffee grower as a small business.

## TOBACCO.

The growing of tobacco in Porto Rico has increased, and the quality of the product has been improved greatly. From the areas where tobacco has been grown for many years, the crop has spread

to suitable fields in nearly all sections of the island. New methods of fertilizing, curing, and fermenting have built up a reputation for Porto Rican cigars, and they may now be found in all the principal cities of the United States. By judicious advertising and a continuous improvement in quality the sale of Porto Rican tobacco has been increased enormously.

Through lack of organization the tobacco growers of Porto Rico miss many opportunities for studying improved methods and for securing better prices. On the other hand, the factory employees are the best organized laborers in Porto Rico and receive the highest wages.

## FRUIT.

The problem now facing fruit growers is not increase in production but improvement in quality of product. Prices throughout the year have been low. Some excellent fruit has been shipped which has brought good prices, but the larger part has been poorly packed or defective in appearance or quality. Much fruit is shipped that should be made into by-products or be discarded. Shipping such fruit results in a loss, not only to the individual grower but to the industry as well. The quality of fruit must be maintained if the industry is to succeed.

Improvement in the fruit industry will come only through organization and closer cooperation, especially in packing and marketing. A distinct gain is made along the latter line in the establishment of community packing houses and in concerted attempts at standardization. Two organizations among the fruit growers that are already proving beneficial are working on community packing houses, the standardization of marks, marketing, and the purchase of supplies. Their organization and work should be strengthened, as it is the most promising move in the industry at this time.

Hastening the coloring of citrus fruit by sweating has been practiced lately. This has been done in order to place the fruit on an earlier market and has resulted in the sale of a great deal of immature fruit. This very short-sighted policy, which has already injured the fruit industry of Porto Rico, should be most earnestly condemned. If the growers themselves by concerted action can not stop the practice, the law should be invoked. Fortunately the pure-food officials, both national and local, have taken up the matter. Fruit growers should cooperate with them to suppress the practice of marketing immature fruit, which, instead of increasing demand and consumption, threatens the very life of the fruit industry.

## MINOR CROPS.

Of the smaller crops, the production of those consumed locally has made the greatest increase. They should, however, be more greatly extended. The fact that 80 per cent of the land of Porto Rico is

idle, while $5,598,799 worth of rice, the principal food crop, is imported, shows the possibilities of this crop on the island. Beans and peas costing $819,703 were imported during the year, yet these can be grown easily in nearly all sections of the island. The major crops give such an impression of easy profits as to overshadow the minor ones, some of which would yield larger returns. Porto Rico is striving to increase its export trade, yet it could with greater profit produce the foodstuffs now imported, thus obviating the danger of food shortage.

## MANUFACTURE OF AGRICULTURAL PRODUCTS.

Porto Rico is especially adapted to carrying on manufactures of certain agricultural products. A large supply of labor is available which can maintain itself at little expense under the favorable living conditions on the island. Tobacco manufactures have reached the greatest development; others are growing and still others are being established. The household industries are best adapted to the habits of the people. The weaving of hats, for example, has grown enormously. Hats valued at more than half a million dollars were exported from Mayaguez during the year.

## AGRICULTURAL LABOR.

Agricultural labor, in spite of a greater demand in other countries, continues to be comparatively plentiful in Porto Rico. The higher cost of living has not been met by corresponding increase in wages, and there has been a great deal of unrest, resulting in strikes in certain industries. Most of the laborers are unskilled and unorganized. They are fairly efficient in doing handwork with tools which they have used through several generations, but they are slow in learning to use machinery and in applying new methods. Aside from the desire to see their children's condition improved, they show little ambition and are especially averse to working for themselves, preferring rather to offer their labor in an often overcrowded market and producing about their homes little or nothing which would reduce the cost of living or tide them over periods of idleness. Emigration is slight and the birth rate is very high, the resultant excess population producing on some plantations, especially in the interior, deplorable economic conditions. It is impossible for the plantation owner to give employment to all the people occupying his land, yet the plantation must support them without return. They thus become parasitic on the plantations or wander down into the already overcrowded towns.

### LIVE STOCK.

Owing to the greatly extended planting of sugar cane, the demand for work cattle has increased, and their value has advanced greatly. Milk has been scarce during the year, retailing at as high as 18 cents a quart, and suffering has resulted.

To grow more live stock, more forage must be grown. The pasture lands of the hills grow scanty grasses, some of which are unpalatable. The station has introduced and is distributing Sudan grass, kafir corn, and other forage plants giving profitable returns outside of Porto Rico. The velvet bean is proving one of the best forage plants introduced, not only for live-stock production but for soil improvement.

As cattle have been bred in Porto Rico mainly for work purposes, the native animals have size and vigor, but their milking qualities should be improved. Owing to the presence of tick fever on the island, considerable risk is involved in importing high-priced, well-bred animals. However, on every plantation where cattle are raised in any number a pure-bred sire could be kept with little risk if carefully handled. The station has tried this plan and, besides, has not only assisted breeders in importing cattle but, to improve the cattle in different sections, has sold at reasonable prices animals bred in the station herd.

Pigs usually are raised singly and subsist mainly upon offal. That they can be raised at a low cost has been demonstrated at the station. Before the industry can be greatly extended, the number of grain and root crops suitable for pig feeds should be increased.

### LANDS.

Although the prices of products have fluctuated somewhat, land values have increased steadily since the American occupation. In spite of this it has been and is difficult for the landowner to secure money on his lands at a reasonable rate. In some cases where he obligates himself to sell his crop to the lender, he can get money at a fair rate, yet this practice is not to be commended. The borrower usually pays 12 per cent, a rate which, while legal on the island, is unreasonable, in view of the very safe security offered, and often disastrous for an agricultural enterprise.

## REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By P. L. Gile and J. O. Carrero.

### INTRODUCTION.

During the year 1916 the investigation of guanos and some studies incident to the investigation of lime-induced chlorosis were completed and the results prepared for publication. New work was undertaken

on the efficiencies of different phosphates in Porto Rican soils. A certain portion of the work accomplished on these subjects was published in various journals, as the detailed results were somewhat technical. A summary of these articles and of progress in the different investigations is given below.

## BAT GUANOS.

Deposits of bat guano are especially common in the Tropics and in subtropical regions, although they are generally of small size. As the fertilizing values of bat guanos and the similar leached bird guanos have never been studied thoroughly, the investigation of Porto Rican bat guanos is of some general interest.

This work, was carried out in considerable detail. Vegetation experiments, which comprised results from over 2,300 pots, were conducted to determine the immediate availability of the nitrogen in 39 samples of guano and the immediate efficiency of the phosphoric acid in 94 samples. Tests also were conducted with many samples to determine the extent to which the efficiency of the phosphoric acid was affected by the kind of soil, the crop, liming, remaining in the soil, the stage of growth of the crop, and the quantity of guano used.

A monetary value was assigned the different guanos based on prices of the fertilizing elements prevailing before the European war. The values of the different guanos examined varied between nothing and $47.60 per dry ton, the average for 247 samples being $7.14. Probably the total quantity of bat guano existing in Porto Rico is worth less than $300,000. It is evident, therefore, that bat guanos will form hardly an appreciable part of the fertilizers consumed on the island. They always, however, should constitute one of the minor sources of fertilizer supply, as even after all the old material has been extracted a small but continuous supply of fresh material worth several thousand dollars annually will be available.

The practice of frequently extracting the fresh guano should be followed, as in all caves except very dry ones the fresh material is more valuable than partially decomposed and leached guano, being worth about $30 per dry ton. Moreover, the fresh material is of fairly constant composition and availability and so may be used without frequent analyses.

## A PLAN FOR TESTING EFFICIENCIES OF FERTILIZERS.

In connection with the work on bat guanos some data were accumulated regarding the proper plan to be used in testing the efficiencies of fertilizers. A discussion of this was presented in a recent paper by the writers [1] and is summarized here.

[1] Jour. Amer. Soc. Agron., 8 (1916), No. 4, pp. 247–255.

Tests of the relative efficiencies of fertilizers, as usually planned, involve the application of only one or two quantities of the standard fertilizer. Relative efficiencies are then calculated on the basis of the relative increases produced by the different fertilizers. It was pointed out that this method is based on the assumption that equal and successive increments of the fertilizer in minimum will produce equal increments in yield and that this assumption is often false. Attention was called to some conditions affecting the manner in which the crop yield increases with increase in fertilizer.

It was proposed that tests of the efficiencies of different fertilizers furnishing the same element should include applications of three to five different quantities of the standard fertilizer, and that from the data of tests so planned the efficiencies should be calculated on the basis of the relative quantities of the different fertilizers required to produce the same increased yields. This method was used in the work with bat guanos.

The advantage claimed for the proposed method is that, being based on no assumption concerning the law of minimum, an accurate comparison is possible irrespective of how the yield increases with increasing amounts of the fertilizer in minimum. The form of the curve, plotted from the increased yields produced by increasing amounts of the standard fertilizers, shows when a calculation of relative efficiencies is allowable and gives some idea of the accuracy of the comparison. As the proposed method involves the idea of always comparing yields of approximately equal magnitudes, an analysis of the crop and a determination of dry matter are not so important as in the old method. This principle of the proposed method is of particular value for vegetation tests in pots where large and small yields are subject to somewhat different conditions in respect to ratio between soil and root volume and total amount of mineral matter supplied in the water.

## THE EFFICIENCIES OF VARIOUS PHOSPHATES IN PORTO RICAN SOILS.

During the past year work was begun on the use of different phosphates on Porto Rican soils. This study is expected to occupy most of the time and facilities available during the present year. By means of vegetation experiments in pots it is planned to determine the relative efficiencies of acid phosphate, basic slag, bone meal, finely ground rock phosphate, and double superphosphate in as many of the different Porto Rican soils as possible; the effect of liming on the efficiency of these phosphates in acid soils which normally would receive lime; and, to some extent, the rate at which the different phosphates become unavailable in various soils. As many soils as possible will be tested in this way. Work was started with soils

in the citrus district where fertilizers are used to the greatest extent and where phosphatic fertilizers are necessary.

The results afforded by vegetation experiments in pots can not be taken as applying in their entirety to field conditions, and such is not the intention in these experiments. For instance, this work will not show the degree to which the soils will respond to phosphatic fertilization in the field with different crops. This can be determined only by field experiments with the different crops, and in some cases this has been done. This work should show, however, the best form in which to apply the phosphoric acid in case phosphatic fertilizers are to be used. Also it should furnish information concerning the length of time the different phosphates remain available in the soils. This information is particularly valuable in fertilizing long-time or permanent crops, like pineapples and citrus fruits.

## LIME-INDUCED CHLOROSIS.

During the last few years more or less work has been done on lime-induced chlorosis as opportunity offered. The results of numerous experiments now seem to show fairly conclusively that the chlorosis of certain plants in highly calcareous soils is due solely to a lack of iron in the plant. The experiments indicate that calcium carbonate causes this lack of iron in the plant by depressing the availability of iron in the soil without having any other secondary effect on the plant.

The study of lime-induced chlorosis thus becomes largely a study of the assimilation of iron by the plant and the factors affecting the availability of iron in the soil. Recently the work was prosecuted along these lines. A test of the availability of certain organic iron compounds in a calcareous soil is being conducted. A series of experiments with rice grown in nutrient solutions was carried out to determine the effect of the reaction of the solution on the growth of rice and assimilation of iron. The results are summarized below. Evidence on the movement of iron in the plant was secured. A report of this is given below.

In connection with some of the direct experiments on the nature of chlorosis it was necessary to ascertain how the absorption of a mineral nutrient was affected by the number of roots supplied with the nutrient. As this work was somewhat technical and probably will be published in a journal, a brief description of the results is given below.

It is hoped that during 1917 the direct experiments on chlorosis and certain parts of the work reported in special articles can be prepared for publication as a bulletin.

## IMMOBILITY OF IRON IN THE PLANT.

Evidence concerning the immobility of iron in the plant after transportation to the leaves was presented in a recent publication of the department.[1]

The observations on the immobility of iron dealt chiefly with its nontransference from leaf to leaf when the plant was insufficiently supplied with iron. When the plant is insufficiently supplied with nitrogen, phosphoric acid, or potash, there is a transference of these elements from old leaves to younger ones where growth is more active. The distinction between iron and the mobile elements was made evident by the growth of rice in media lacking in these elements. Rice grown for a time with iron and then without iron commenced to show chlorosis and die in the upper leaves, the lower ones remaining green. When the plants were grown in media lacking nitrogen, phosphoric acid, or potash, the lower leaves died first, these mobile elements being translocated to the new leaves.

This evidence concerning the immobility of iron was supported by observations on plants affected by lime-induced chlorosis, by the local effect produced by brushing portions of chlorotic leaves with iron salts, and by ash analyses of old and young leaves.

If iron is really immobile after it has once been transported to the leaves, as the evidence seems to show, certain peculiarities in the behavior of plants affected with lime-induced chlorosis are explained easily. For instance, it is clear that a plant as a whole or certain parts of a plant might lack iron, while other parts, as the lower leaves, might contain a sufficiency. Thus, in analyzing chlorotic plants to demonstrate a lack of iron it probably would be well to analyze more than one part, as both upper and lower leaves. Occasional anomalous results that were secured in comparing the iron contents of green and chlorotic plants doubtless were due to including parts of chlorotic plants that contained sufficient iron.

The immobility of iron in the plant also explains the temporary nature of the effect produced by spraying chlorotic plants with iron salts. Repeated observation showed that whereas leaves of plants affected with lime-induced chlorosis became perfectly green on spraying with iron salts, new leaves, that appeared directly or soon after the treatment, were chlorotic. This could hardly have been due to the fact that only enough iron penetrated the treated leaves to suffice for their needs, but doubtless was due to the immobility of the iron after entering these leaves. Also, it probably is due to the same cause that the method of applying iron salts to the cut surfaces of chlorotic vines has proved more successful in France than spraying the leaves.

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[1] U. S. Dept. Agr., Jour. Agr. Research, 7 (1916), No. 2, pp. 83–87.

## THE ASSIMILATION OF IRON BY RICE FROM CERTAIN NUTRIENT SOLUTIONS.

As calcareous soils are slightly alkaline in reaction, it was considered important to determine whether rice, which becomes chlorotic on such soils, is sensitive to the reaction of the medium in which it is grown and whether the reaction of the medium affects the assimilation of iron. The results of this investigation have been published already.[1]

The growth of rice was measured in acid, neutral, and alkaline nutrient solutions containing 0.002 and 0.008 gram iron per liter from ferrous sulphate, ferric chlorid, dialyzed iron, ferric citrate, and ferric tartrate, and the amount of iron assimilated was determined by analyses of the plants. When certain quantities and kinds of iron were used, the growth of rice and the amount of chlorosis varied considerably in the nutrient solutions with different reactions; but with the other quantities and kinds of iron the reaction of the solution had little effect on the plants. In most cases growth and quantity of iron assimilated were greater in acid solutions and least in solutions made alkaline by carbonate of lime. With ferric tartrate as a source of iron, however, growths made in the three solutions were practically equal.

The data show quite clearly that rice is sensitive to the reaction of the nutrient solution only as the reaction affects the availability of the iron. This confirms the results of experiments conducted with rice grown in calcareous soils in regard to the appearance of chlorosis.

Incidentally this investigation brought out other facts of importance in regard to the assimilation of iron by rice. Further evidence was added to that obtained in previous experiments showing that very finely divided or colloidal iron is not available to rice.[2] Evidence also was obtained indicating that rice is able to assimilate sufficient iron from exceedingly dilute solutions, it appearing from calculations given that sufficient iron doubtless can be secured from solutions where the concentration of truly soluble iron is 1 part or less in 10,000,000.

This work, while indicating that certain factors probably influence the availability of iron in soils, also points out the great difficulties that would attend an attempt to determine directly the amount of available iron in different soils.

## THE ABSORPTION OF NUTRIENTS AS AFFECTED BY THE NUMBER OF ROOTS SUPPLIED WITH THE NUTRIENT.

In studying the chlorosis of rice, it became necessary to know whether a plant could absorb sufficient iron with part of its roots, provided all of its roots were supplied with all other essential nutri-

[1] U. S. Dept. Agr., Jour. Agr. Research, 7 (1916), No. 12, pp. 503-528.

[2] U. S. Dept. Agr.. Jour. Agr. Research, 3 (1914), No. 3, pp. 205-210.

ents. A general study was made of this question and the results submitted for publication.[1]

The experiments were conducted with corn and rice in water cultures, the plants being grown with part of their roots in a complete nutrient solution and part in a nutrient solution lacking one element only. In this way the absorption of nitrogen, phosphorus, potassium, and iron was studied. In some tests one-half the roots of the plants were maintained in a solution lacking one of these elements, and in other tests three-fourths or two-thirds of the roots.

The results obtained were surprisingly uniform in some respects. It appeared that when a portion of the roots was not supplied with one element the plant could not absorb a maximum amount of this element with the rest of its roots. The fewer the roots that were supplied, the less nearly the plant attained a maximum absorption of the element. A curve was plotted showing what portion of the maximum absorption could be expected with any fraction of the roots supplied with the element. This curve agreed with Mitscherlich's formulation of the law of minimum.

Under the conditions of these tests, plants with half their roots absorbed 0.76 as much nitrogen or phosphorus as plants with all their roots in the complete solution. The similar figure for potassium or iron was 0.66. Increasing the concentration of the element in question in the complete solution did not alter appreciably these figures. These results were obtained under conditions where the total amount of the element afforded part of the roots was equal to or in excess of the amount needed for maximum absorption.

Although the plants never attained a maximum absorption of an element with a portion of the roots, the amount of the element absorbed per gram of roots increased markedly as the number of roots supplied with the element decreased. With only one-fourth of the roots supplied with nitrogen in the complete solution the amount of nitrogen absorbed per gram of roots was a little more than double that absorbed per gram of roots by plants with all their roots in the complete solution.

As the results obtained are due to the way the plant functions in absorbing mineral elements, they are, to a certain extent, applicable to soil conditions and have a direct practical bearing. It is obviously important to apply fertilizers so that as far as possible all the plant's roots will be supplied with the fertilizing element or elements. The lateral diffusion of fertilizing salts being small, this can best be brought about by distributing the fertilizer over the whole area occupied by the roots.

When fertilizers are applied to only part of a plant's roots, various conditions will determine how completely the fertilizer is absorbed.

[1] U. S. Dept. Agr., Jour. Agr. Research, 9 (1917), No. 3, pp. 73–95.

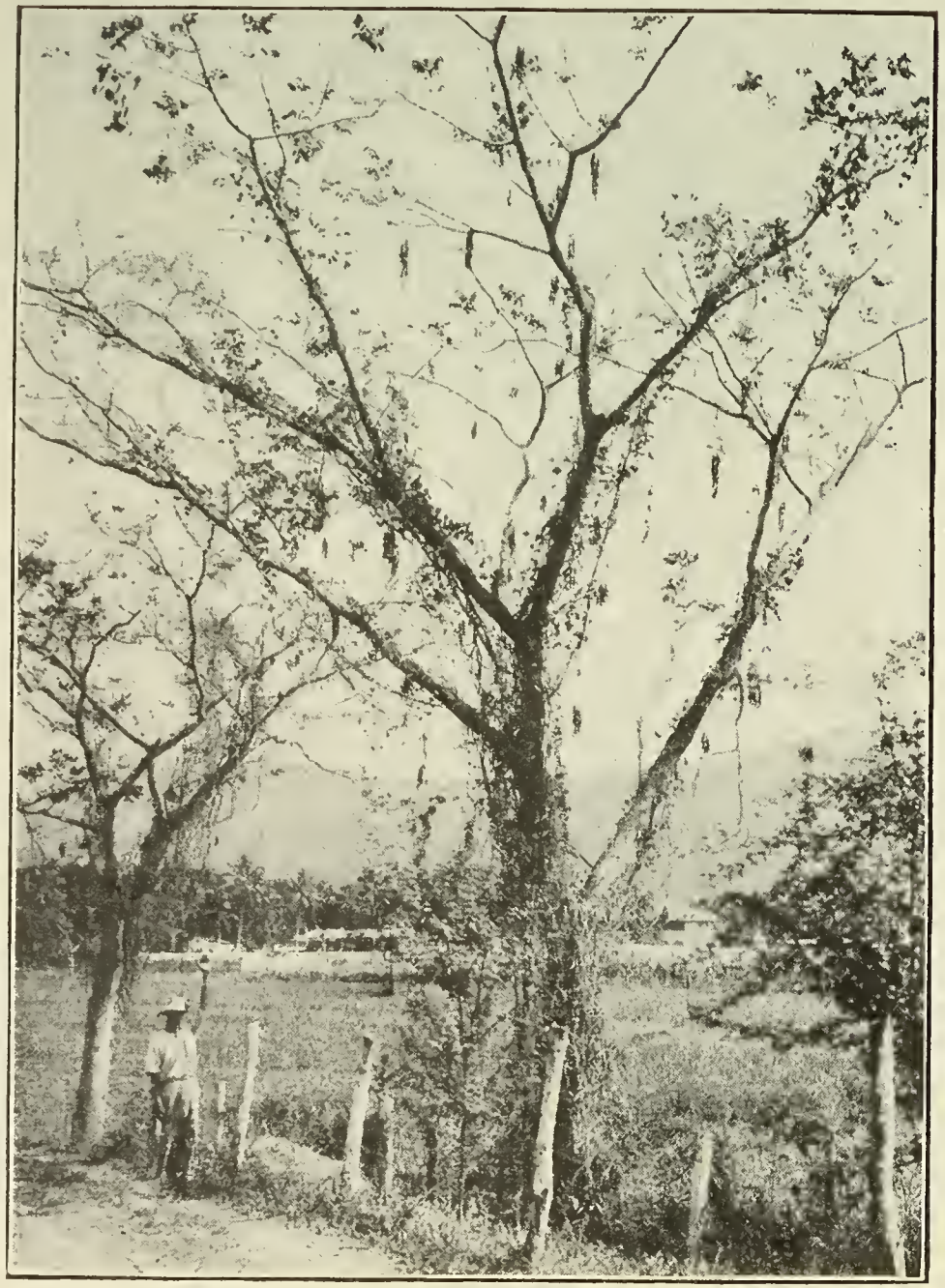

FIG. 1.—VELVET BEANS GROWING TO TOP OF JOBO TREE.

FIG. 2.—SEEDLINGS FROM CAMBODIANA MANGO.

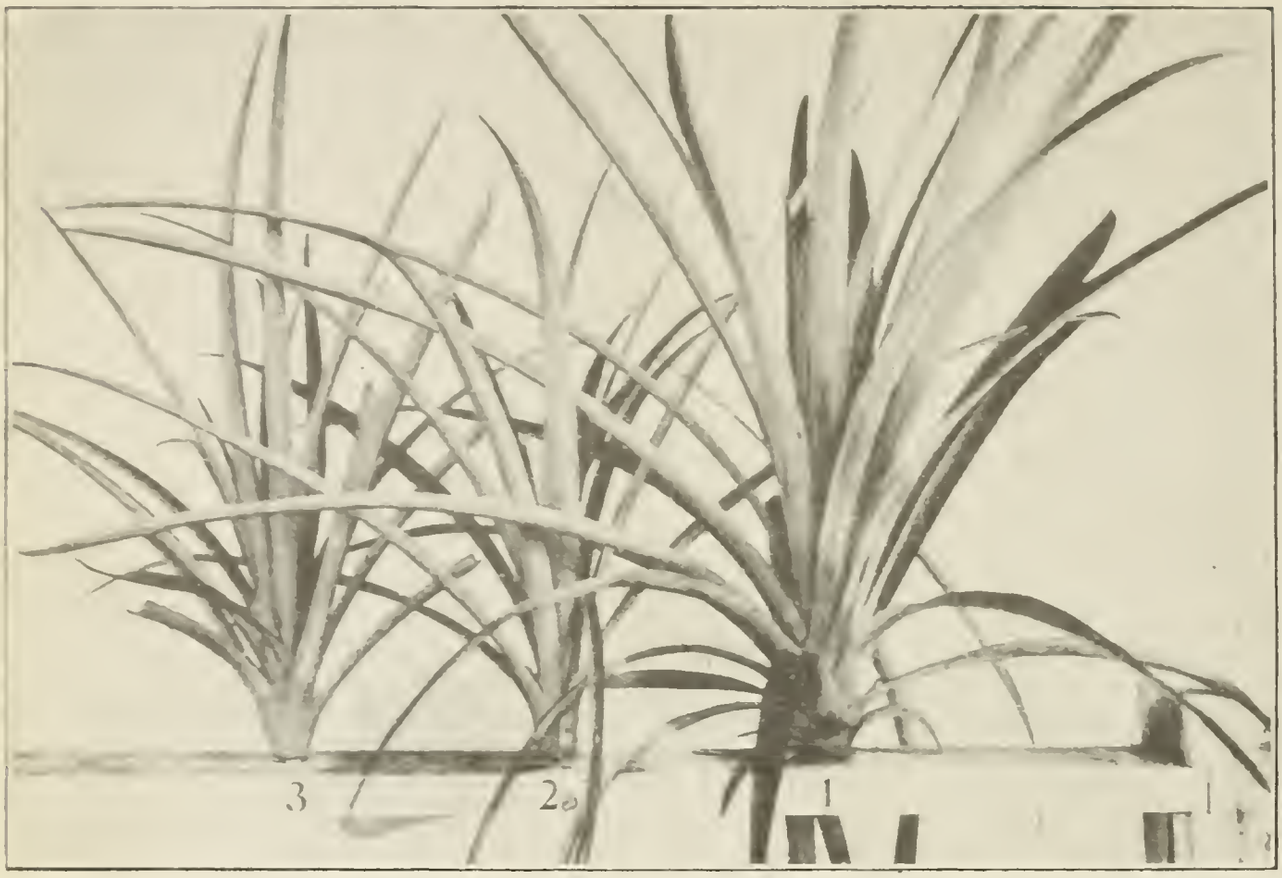


FIG. 1.—PINEAPPLES AS AFFECTED BY (1) COMPLETE FERTILIZER WITH NITROGEN FROM AMMONIUM SULPHATE; (2) COMPLETE FERTILIZER WITH NITROGEN FROM SODIUM NITRATE; (3) NO FERTILIZER.

FIG. 2.—VARIATION IN MURTA COFFEE; ARABIAN TYPE AT RIGHT, ROSETTE TYPE AT LEFT.

The exact figures obtained in this work evidently will not apply to field conditions. For instance, there is a tendency for root growth to become more luxuriant in those zones where the fertilizer is located. This would tend to make the absorption of poorly distributed fertilizers more complete than would appear from the figures obtained in this work. It also should be borne in mind that only under very exceptional field conditions are plants entirely dependent on a fertilizer for their supply of a nutrient. We may say that most of the roots are supplied to a greater or less extent with all the nutrients. This would tend to make the absorption of fertilizer applied to a few roots less than the figures obtained in this investigation.

The quantity of fertilizer applied to a few roots would also affect the completeness of absorption. If the quantity were nearly or quite equal to the plant's requirements, the absorption would not be complete; but if the quantity were much less than the maximum amount required, the absorption doubtless would be nearly complete.

Besides the above, soil conditions also influence the ability of a plant to effect a maximum absorption of poorly distributed fertilizer. Loss by leaching, fixation by the soil, bacterial action, etc., are all important factors which, as a rule, would tend to make the absorption of fertilizers less complete than would appear from the figures of this work.

The fact that in this investigation plants were able to effect a maximum absorption of all the nutrients only when all their roots were supplied with all the nutrients is suggestive for soil studies. As plants doubtless assimilate mineral nutrients from aqueous films surrounding soil particles, an apparently logical conclusion of the above fact is that a maximum absorption of nutrients would be possible theoretically only when all the films surrounding the soil particles contain all the nutrients.

## REPORT OF THE HORTICULTURIST.

By C. F. Kinman.

### PINEAPPLES.

During the past two years work with pineapples has included a comparison of the effects of nitrate of soda and sulphate of ammonia in a complete fertilizer, fertilizer experiments carried on in cooperation with planters, and tests of general cultural methods and of varieties.

The results from the tests of nitrate of soda and sulphate of ammonia have been very striking (Pl. II, fig. 1). Both suckers and slips of plants, including Red Spanish and Cabezona, the common commercial varieties in Porto Rico, and the variety Trinidad, were set in

beds which had been prepared in the usual way. Immediately after planting, all were given a light application of fertilizer containing 4 per cent nitrogen and 8 per cent phosphoric acid, and a few weeks later a mixture containing nitrogen, phosphate, and potash. The nitrogen was added in the form of nitrate of soda to duplicate plats, and sulphate of ammonia to others, while acid phosphate and sulphate of potash were applied to all plats. One planting was made in 1914 and one a year later, both in September, a time when rainfall is plentiful and thrifty seed plants available. After the seed plants had been harvested, they were left unplanted for a few days and became light green shaded with red from exposure. Twenty days after planting, it was noted that the pines on the plats fertilized with sulphate of ammonia had regained their thrifty dark-green color, but no change was noticeable in those on the other plats. The plants on the sulphate of ammonia plats continued their vigorous growth and maintained their healthy color throughout the year, but those on the other plats made a very slow growth and remained abnormal in color. The effects of the different forms of nitrogen on the growth of the plants was less marked on the Red Spanish variety than on the others. In no case did the plants supplied with nitrate of soda show any marked improvement over the unfertilized plants, and all were worthless from a commercial standpoint.

In March and April, the normal fruiting season for the Red Spanish variety at Mayaguez, 92 per cent of the plants given sulphate of ammonia bore fruits, all of which were of good marketable size, weighing from 2 to 4½ pounds, but only 34 per cent of the plants giving nitrate of soda produced fruits, the largest weighing only 1½ pounds and a large percentage less than half as much. Due to unfavorable weather conditions, few of the plants of the other varieties bore fruit, and all that fruited were in the plats fertilized with sulphate of ammonia.

From these results it is evident that, in soil similar to that at the experiment station at Mayaguez, nitrate of soda should not be used for fertilizing pineapples and that experiments should be conducted to determine its value in other soil types before it is used commercially.

## COCONUTS.

The experiments in coconut fertilization discussed in former reports have progressed satisfactorily through the year. The plats given a complete fertilizer continue to produce much larger crops than those given an incomplete mixture, whereas in the group of plats where either nitrogen, phosphate, or potash is omitted from the fertilizer the yield is little heavier than that from the check plat. Although the complete fertilizer has greatly increased the

number of nuts harvested, the average diameter of the nuts has remained practically the same in all plats throughout the experiments.

A number of coconut trees were selected for special study. The nuts from these individuals have been measured for several consecutive harvests to determine whether there is a constant relation between size and shape of husk and nut, whether the size of nut or thickness or shape of husk borne by a single tree varies at different times of the year, and whether there is any marked fluctuation in the size or shape of nuts or husks in the course of a few years. These measurements have been made during only a few harvests, but the results indicate that the product from a given tree varies little from harvest to harvest. Plantings have been made from seed of selected trees whose records of yields and of nut characteristics are at hand for the purpose of comparing the product of the new trees with their parents. As there is much to be learned in regard to the selection of seed nuts, the results of this work should be valuable to persons intending to plant coconut groves.

## MANGOES.

A large number of mango trees of both imported varieties and seedlings from imported kinds are under observation at the experiment station. Of seedlings from 3 to 5 years old in the field, only those from the variety Cambodiana have made a uniformly thrifty growth (Pl. I, fig. 2). In rapidity of growth, color and shape of leaf, and general tree characteristics they are very uniform and can not be distinguished from grafted trees. In plantings from other varieties, including Amini, Sandersha, Totafari, Bulbulchasm, Mullgoa, and Alphonse, a small percentage of the trees have been thrifty; the others have made only a fair or poor growth. Seed of other varieties have been planted in the hope of finding some which will breed true from seed and thereby facilitate the distribution of superior mangoes over the island.

A few fruits borne by seedlings of Sandersha were large and similar in color, but somewhat different in shape, flavor, and color of flesh from the parent fruit. The seedlings from other imported varieties have not borne yet, but they are expected to fruit in one or two seasons.

During the year a large number of grafted and seedling trees of superior varieties have been distributed to planters, and the number in the orchards at the experiment station has been increased. As seedlings of the varieties Cambodiana, Sandersha, and Alphonse grow more rapidly than the common Porto Rican kinds, a result which may be accounted for by their larger seed, they are ready earlier for use as stocks. Practically all of them are large enough for this use before the severe winter drought starts, which is a

decided advantage, owing to the difficulty of keeping the young plants from being seriously injured by thrips during the dry weather and thereby made useless for stocks.

The receptacles used for growing stock plants have been for the most part lightly made of 6-inch concrete tile 1 foot long and closed at one end by concrete except for the drainage openings. As these pots, being deep, are suited to the long taproot of the mango and hold a good quantity of earth, they are very satisfactory for this use.

Transplanting tests have resulted very satisfactorily with both nursery plants and older trees when the operation was performed at a time when the last flush was well matured and rainfall was abundant. Greatest success followed severe pruning, especially of trees a few years of age, and removal of a ball of earth with the roots. A number of trees of imported kinds were transplanted without loss after they were several years old and had borne two crops of fruit.

In testing the advisability of leaving long or short stems on the fruits when removing them from the tree, it was found that a stem somewhat longer than the fruit stock should be left if the fruit has not become fully ripe on the tree. The pressure of the juice is so high in fruits that have not softened that a stream is forced out through the large cells of the fruit stock, which, if the fruit stock is separated from the branch, leaves open passages into the base of the fruit through which infection enters after the fruits have cured a short time. When a stem slightly longer than the fruit stock is left this trouble is avoided. Lots of 100 each of long and short stemmed fruits of the Porto Rican type of mango known as Blanco were harvested when they were fully grown and had just started to soften, and were stored in the laboratory. In six days 12 long and 60 short stemmed fruits were decaying at the base. Of the long-stemmed specimens which decayed, probably the skin at the union of the stem and fruit had been broken by accident in handling.

## MISCELLANEOUS INTRODUCTIONS.

*Sweet potatoes.*—Twenty varieties of American-grown sweet potatoes sent to the station in 1911 by the Bureau of Plant Industry, United States Department of Agriculture, have all lost their characteristic flavor, and at least some of them have developed a coarseness not common in the North. These importations are not, in general, superior in flavor or texture to the types which have been grown in Porto Rico over a long period of years. The Office of Foreign Seed and Plant Introduction, United States Department of Agriculture, has sent to this station a new stock of the same varieties, which will be planted side by side with corresponding varieties of the former importation, to study further the apparent deterioration resulting from tropical conditions.

Among the common kinds of sweet potatoes found on the island one with superior qualities, known locally as mamey, is being propagated for distribution. Although it has borne small crops in the heavy soils of the experiment station and is reported as producing small crops in other localities, its excellent table qualities justify its extensive planting for home use.

*Phaseolus mungo.*—Two types of this leguminous plant, one of a luxuriant and one of a dwarfed habit of growth, which were received from the Philippine Islands, have proved very thrifty and prolific at Mayaguez when planted during the spring, although poor crops have resulted from summer, fall, and winter plantings. The cooked seed of this plant is palatable as food, and its heavy foliage makes it valuable as a soiling or cover crop. As *Phaseolus mungo* will probably grow well in most parts of Porto Rico, it should be tested thoroughly in all localities, and seed has been distributed to many planters for this purpose.

*Banana.*—A variety known as Hua Moa, which was sent to the experiment station from Hawaii several years ago and until the past two years has been given the same care as other varieties of bananas, produced unthrifty plants with small clusters and fruits. During the past two years good applications of stable manure have resulted in fair yields of good-sized fruits. The fruit of this variety is suitable for cooking, and it is thought by many Porto Rican families to be superior to other varieties for this purpose.

## REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McClelland.

### COFFEE.

The testing of coffee varieties new to Porto Rico is being continued, and such varieties as appear promising are being distributed widely.

During the past year a sufficiently extensive planting of Robusta coffee was made to demonstrate the possibilities of this type under local conditions. Its quality is considered inferior to that of the Arabian type grown in Porto Rico, but its heavier yield, judging from the few mature trees on the station grounds, makes it a promising crop for supplying a low-priced market. This coffee has matured much later than the native coffee, the main crop having ripened here in late winter and early spring rather than in autumn. This in one way is an advantage, as it furnishes employment to pickers in a dull season. The rank growth of the trees necessitates topping at 7 or 8 feet to facilitate picking.

The growth of San Ramon coffee has shown that it will succeed under local conditions. Its stocky form makes it desirable for planting in exposed situations. Where the typical Arabian coffee thrives,

however, it should not be replaced by San Ramon, as the latter would probably bring a lower price.

The coffee received from the Congo as *Coffea dewevrei* has shown a very wide variation between individuals as regards vigor, growth, foliage, flowers, fruit, and time of maturing. Some trees are very vigorous and very prolific, and if the flavor of the product proves acceptable these will be valuable acquisitions. Individual records are being kept for the more promising trees.

The coffee known here as Murta has proved to be a mongrel. The inheritance of different forms in this coffee is being studied. Of 1,803 seedlings from unprotected blossoms, 543 were of the ordinary Arabian type and the others ranged from the Murta type to a small dwarf with many upright branches resembling a tiny green rosette (Pl. II, fig. 2). The total number of seedlings remaining when counted was approximately two-thirds of the number of seed planted. As some plants had been killed by a fungus before the count was made, and others doubtless were lost in cultivating, naturally the most vigorous type was found in excess of its true proportion. During the present blossoming season a number of branches were bagged to afford material for further study.

The experimental transplanting of coffee trees mentioned in the last report continues to show wide differences both in growth and yield as a result of the method followed. The results are considered of sufficient value to warrant a separate report.[1]

The fertilizer experiments continue to show beneficial effects, both on growth and crop, from the application of nitrogen. Cooperative fertilizer tests, in which nitrate of soda is used in different amounts, have been started on two coffee plantations.

A native tree of dwarf growth, *Erythrina corallodendron*, not hitherto used locally as coffee shade, is being tested for this purpose. Its easy propagation (nearly all cuttings striking root), its rapidity of growth, and its dwarf habit (permitting the lightening of shade without damage to the coffee below) are all points in its favor. Its development in full sunlight is much more vigorous than in shade. The question of new shade trees for coffee is an important one, as some of those used at present harbor pests very destructive to coffee.

Plantings without shade of different coffee varieties also are being made to compare their relative vigor in the open.

## CACAO.

For a number of years records have been kept of the number of pods produced by individual cacao trees. These are being continued and are now being amplified by recording the weights of fresh pods,

[1] Porto Rico Sta. Bul. 22 (1917).

number of seeds, and weight of seeds. Of the cacao planting made in the spring of 1909, a little more than one-fourth of the trees produced no crop in the calendar year 1915. The others averaged nearly 10 pods per tree. In the planting made in 1903 about the same proportion of trees failed to produce, but the average yield from the fruiting trees was 6½ pods per tree. Attempts to propagate cacao from cuttings have been unsuccessful.

## VANILLA.

Encouraging results with vanilla have been obtained which show this to be a promising crop for Porto Rico. It requires careful attention and a great deal of labor, but with proper conditions large returns may be secured from a small acreage.

Fifteen out of eighteen 3-year-old plants of *Vanilla planifolia* came into production during the year. The yield was a little more than 5 pounds of cured vanilla, which sold at $2.50 per pound. Had an acre been planted the gross returns at the same rate of production would have amounted to nearly $400.

A Philadelphia firm, which deals in vanilla beans exclusively, wrote: "Regarding the vanilla sent us, value of same compares favorably with Bourbon or Java vanilla in same grades, or the vanilla produced in Guadeloupe. While the flavor is very pungent, being very similar to the Java variety, we believe that results from same would prove very satisfactory. Any well-cured vanilla, so long as it is of sweet flavor and sound keeping qualities, is always marketable."

The maximum production for a single vine was 131 pods; the average production, 68 pods. The longest pod measured 9 inches. As only a little over half the pods were 6 inches or more in length, and as one 8-inch pod weighs as much as two 6-inch pods and is also preferable to the latter, it is thought that the product would have been of higher grade had fewer pods been pollinated. As on most vines the number of blossoms which appear is far greater than the number of pods which the vine can produce, the size of the crop can be exactly regulated in the pollination. Experiments are planned to investigate this phase of vanilla culture.

Curing was effected by scalding, sweating, and then spreading the pods between the folds of a woolen blanket placed in the sun. This method was not entirely satisfactory, as many pods, through blistering, lost both in weight and appearance. Other methods will be tried with the new crop. The pods which cured well averaged 155 per pound for 6-inch pods, 112 for 7-inch pods, and 78 for 8-inch pods. For the crop now being produced by the same vines, the number of blossoms pollinated per cluster was greatly reduced, and the pods are far superior to those of the preceding crop.

In crossing vanilla species some very marked modifications in the shape of the resulting pod have followed the application of foreign pollen. The typical, normal, well-developed fruit of *Vanilla planifolia*, as exemplified by those produced at the station, is a long, fairly slender, trilateral capsule, tapering at the stem end, but carrying its fullness well down toward the blossom end. The fruit of the other vanilla species used in crossing with *V. planifolia* is of the "vanillon" type, a shorter, fleshier pod of fairly uniform thickness or tapering slightly near the blossom end. Where *V. planifolia* was fertilized with pollen of the vanillon type, the resulting pods were well filled out at the stem end and tapering at the blossom end, tending in this way to resemble the typical vanillon form. Where flowers of the vanillon type were fertilized with *V. planifolia* pollen, the resulting pods were larger at the blossom end than at the stem end, caricaturing, in a way, the *V. planifolia* form.

A new planting has been made for further tests of the effects of light and dense shading, different pruning systems, the removal of superfluous blossoms, and the pollination of few to many blossoms per cluster.

Vanilla will grow in quite heavy shade, but that this may easily become too dense for its best development was demonstrated by a planting made in a trench filled uniformly with forest trash and loosely bricked over, to which different degrees of artificial shade were supplied, ranging from a dense shade to full sunlight. In dense shade the vines were spindling, with long internodes, whereas in light shade or full sunlight their development was very vigorous, although the leaves on the unshaded vines were somewhat yellow. In some instances, where there is full exposure to the sun, the vines are burned at the point where they bend over the support, which severs the growth beyond this point from the rest of the vine. Where the shade plants have been severely pruned, the unaccustomed exposure to the sun under field conditions has worked serious damage to the vanilla, causing the burning and rotting of many leaves.

## MAHOGANY.

The trees of *Swietenia macrophylla* continue to show adaptability to local conditions. In a planting made at the station the average height at three years from seeding was 16 feet, the maximum height 30 feet. Such rapidity of growth in a valuable timber recommends it for general planting.

FIG. 1.—FEMALE AND MALE TICKS, UNENGORGED (× 5).

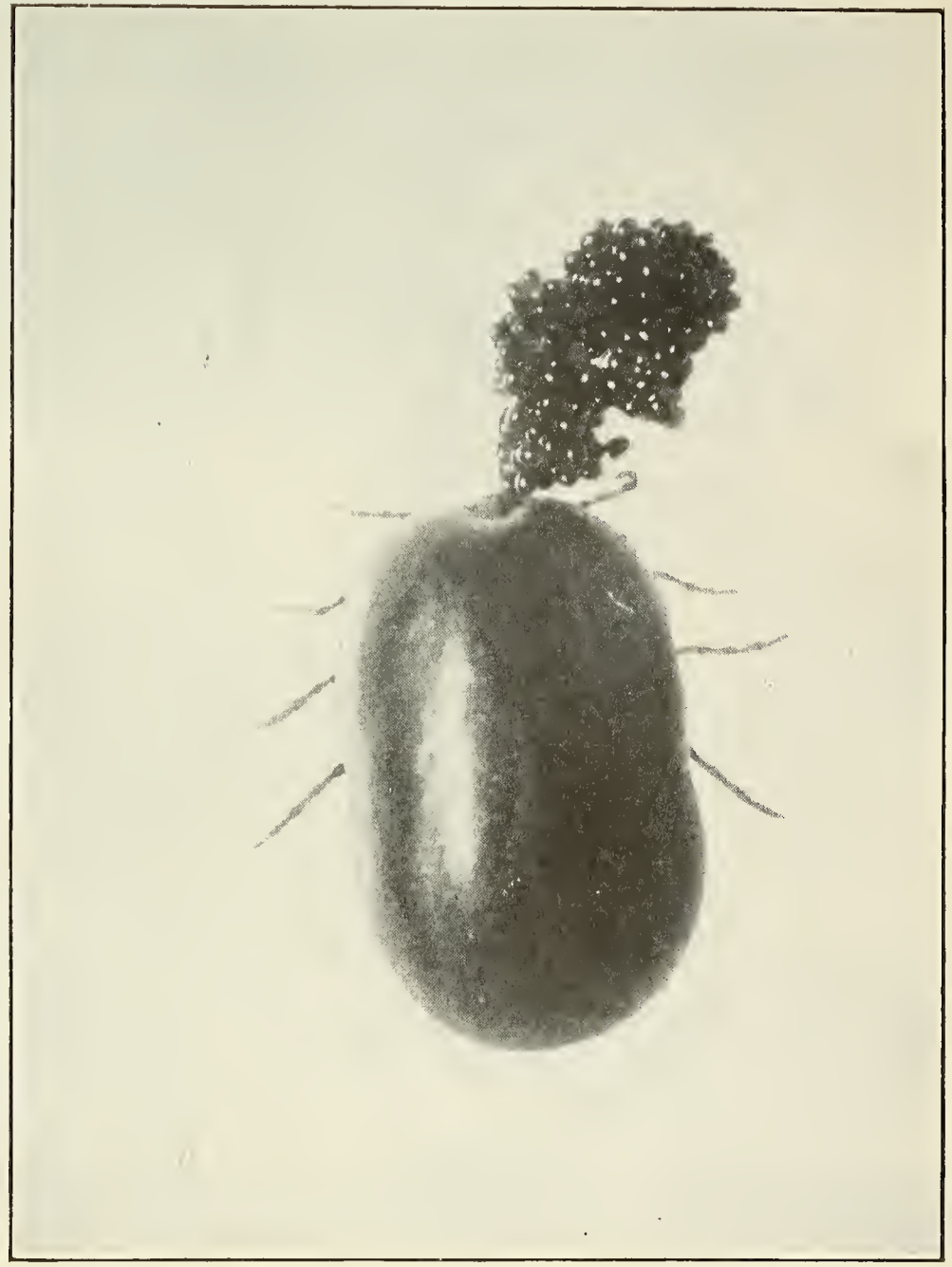

FIG. 2.—ENGORGED FEMALE TICK WITH NEWLY LAID EGGS (× 5).

CATTLE TICK (MARGAROPUS ANNULATUS AUSTRALIS).

# REPORT OF THE ENTOMOLOGIST.

By R. H. Van Zwaluwenburg.

## INTRODUCTION.

During the past year attention has been given chiefly to life-history studies of the changa and cattle tick. Work on the former has been brought to a close and is being prepared for publication. Experiments in trapping to reduce the numbers of the May beetle gave encouraging results and are being continued. Study on the coffee weevil was stopped temporarily by the comparative scarcity of the insect during the past year. Several press articles in both English and Spanish have been issued on beekeeping and on miscellaneous entomological subjects.

## THE CHANGA.

The changa, or mole cricket (*Scapteriscus vicinus*), requires a year for the complete development of a generation. The egg stage requires about three weeks; the development from hatching to the final molt, some nine months; and the preoviposition period, between two and three months. Egg laying is most common during the spring months, and the night flight of adults most marked during November and December.

Adults captured at lights during October and November were more generally females than males. Should this disproportion between the sexes be constant, the value of using trap lights is obvious, especially since most of the females taken during the early fall have not yet laid their eggs. Observations on these points are being continued.

The most satisfactory control measure for the changa in small areas, such as garden plats, was found to be the use of poisoned bait. Persistent use of a mixture of flour or cornmeal and an arsenical will rid an area of the mole cricket and make successful gardening possible even in the most heavily infested areas. Repellents were found to be of little practical value. Flooding land for 24 hours or more may be practical in a few localities, as flooding forces nymphs and adults to the surface, where they fall a prey to insectivorous birds. The eggs of the changa fail to hatch after submersion for a day or longer.

## CATTLE TICKS.

Two varieties of ticks infest cattle in Porto Rico. The more common is the Australian tick (*Margaropus annulatus australis*) (Pl. III). The typical *M. annulatus* of the Southern States is also present, but in much smaller numbers.

Control of the tick by starvation or dipping is dependent for success upon an exact knowledge of the parasitic and nonparasitic development of the acarid in the locality in which control work is to be done. This work is well under way, and data are being collected on the variation of the stages during the different seasons of the year.

At Mayaguez the Australian tick required 20 to 22 days for its development on the host during the fall months. Hence, if local eradication of the tick is attempted, applications of dips, sprays, or smears should be renewed about every three weeks to prevent the maturing of fresh generations. The minimum egg period under natural conditions was found to range from 36 days, beginning in February, when the average mean temperature was 74.7° F., to 23.5 days in September, when the average mean temperature was 79.6° F. The maximum starvation period of ticks hatching in April was found under natural conditions to be 94 days. Seed ticks protected from rain and direct sunlight had a maximum starvation period of 108 days.

### MAY BEETLES.

White-grub injury to cane was especially frequent during the past year, at least on the western half of the island. Some preliminary experiments with trap lights were made which seem worth continuing. A 400-candlepower gasoline lamp, placed near the ground, was operated as soon as the spring flight of the beetles began, and it attracted the large common species of Lachnosterna, as yet undescribed, in large numbers. Males and females were captured in about equal numbers. Only about 17 per cent of the females had completed egg laying. Flight was confined to the early hours of the evening.

White-grub injury is more severe on ratooned cane. Although one of the most obvious control measures is the discontinuance of ratooning, this is not often desirable. The smaller mills, which are supplied by a comparatively small acreage of cane land, can ill-afford to lose the extra time required for a planted crop to mature. Experiments on ratoon cane with poisons and fumigants applied to the soil are now under way.

### A CRICKET ATTACKING SEEDLINGS.

Seedlings of various kinds in the station plant houses were attacked severely by both the young and adult *Amphiacusta caraibea*, a dark-brown cricket, which is almost as common indoors as out. This insect is particularly fond of cool, moist locations. The female is wingless; the male is the common "grillo," which chirps so long and shrilly indoors. This species has been recorded as a household

pest of foodstuffs. The damage done to plants is similar to that caused by cutworms and is even mistaken for the work of changas, for this cricket sometimes burrows beneath the plant and feeds from below in much the same way as the mole cricket. Screening seed beds does not afford complete protection, for the eggs are dropped through even a very fine meshed wire. Flour and Paris green were used successfully against this insect.

The egg of the cricket is subelliptical, with the ends somewhat pointed when laid. It is curved slightly on its axis and is yellowish white, with a dull, unmarked surface. Five eggs averaged 1.9 millimeters long and 0.7 millimeter wide. One female laid 59 eggs in captivity. The eggs usually are deposited singly in the upper inch of soil, but are sometimes dropped promiscuously on the surface. They hatch in about a month.

## BEES.

The heavy summer and fall rains throughout the island resulted in a very poor honey crop during the past year. In the region of Aibonito, where, as a rule, five periods of guamá bloom may be counted upon annually, there were only two bloomings of which the bees could make any use.

Weighing experiments with shaded and unshaded colonies showed that shade is not so important a factor in honey production as it was thought to be, even in the hotter climate of the coast. No striking or consistent difference in production was evident between shaded and unshaded colonies. Colonies exposed to direct sunlight are not so tractable as those of the same race in shaded locations. Bottom-board ventilation is advisable with colonies both in sun and in shade.

Experiments are under way which lay particular stress on wax production rather than on honey production. With the present low prices of honey, and with the high cost of transporting such a bulky article from inaccessible interior points, increased wax production is a logical development of the beekeeping business.

There is at present a tendency toward a centralization of the industry. Small beekeepers are becoming discouraged at crop failures and low prices, and it seems to be only a question of time before beekeeping will be continued only on a comparatively large scale.

## MISCELLANEOUS NOTES.

By far the most satisfactory spray material yet found for the majority of Porto Rican insects is the paraffin-oil emulsion used by the Bureau of Entomology, of the United States Department of Agriculture, in its work in Florida. It is more effective than homemade lime-sulphur and is much cheaper and less troublesome to prepare.

During the year there was a serious outbreak of the yellow aphid (*Sipha flava*) on young sugar cane at Ponce, Porto Rico. The growth of the cane was severely retarded, and in a few cases death resulted from the insect injury. The outbreak eventually was brought under control by natural enemies.

The only relative of the sawfly family recorded from the West Indies is *Stericiphora zaddachi*, the larvæ of which feed on the leaves of seagrape (*Coccoloba uvifera*) and icaco (*Chrysobalanus icaco*). The wings of the adult are transparent, with black veins; the body in life a bright crimson. The male is much smaller than the female and appears to have four antennæ, due to the forking at the third antennal segment. The eggs are subovate, with the base prolonged to form a short stalk. When first laid they are red, but as the embryo develops they change to pink. They are laid on the underside of the leaf in clusters of 26 to 31, the eggs in each cluster being regularly spaced. The egg averages about 1.8 millimeters high and 1.1 millimeters broad. The larvæ are gregarious and feed on the leaf with the terminal abdominal segments curled about the twig or leaf on which they rest, in the typical sawfly manner. When the larvæ are disturbed, the abdomen is curved forward over the head in a threatening manner. In the earlier stages they are a dirty white in color, with a pinkish tinge on the thoracic and last three abdominal segments. The last instar is very different in appearance and quite striking. The head and dorsum are shiny black; the first thoracic segment, the procoxæ, and the last abdominal segment, carmine; the sides of the body wine colored. Pupation takes place on the leaf, usually within a fold or roll. The tough brown pupa case, composed of a secretion mixed with leaf particles, is roughly oval, with one end truncate. Females averaged 16.7 days in the pupa, and males 18.8 days.

The termite mentioned in the 1915 report of the entomologist as tunneling in furniture and woodwork was named incorrectly there. The insect is a species of Cryptotermes.

## REPORT OF THE PLANT PATHOLOGIST.

By E. W. Brandes.

### INSPECTION TRIPS AND IDENTIFICATION OF PLANT DISEASES.

During the past year it was possible to make inspection trips which covered many of the important agricultural districts of the island. Many specimens of diseases of economic plants were collected and sent to the laboratory to be identified. Although no exact quantitative surveys were attempted, the trips were of great value in indicating the relative prevalence of the better known fungus diseases. An index was thus obtained to the logical order of procedure in undertaking investigations of the various diseases. A number of new dis-

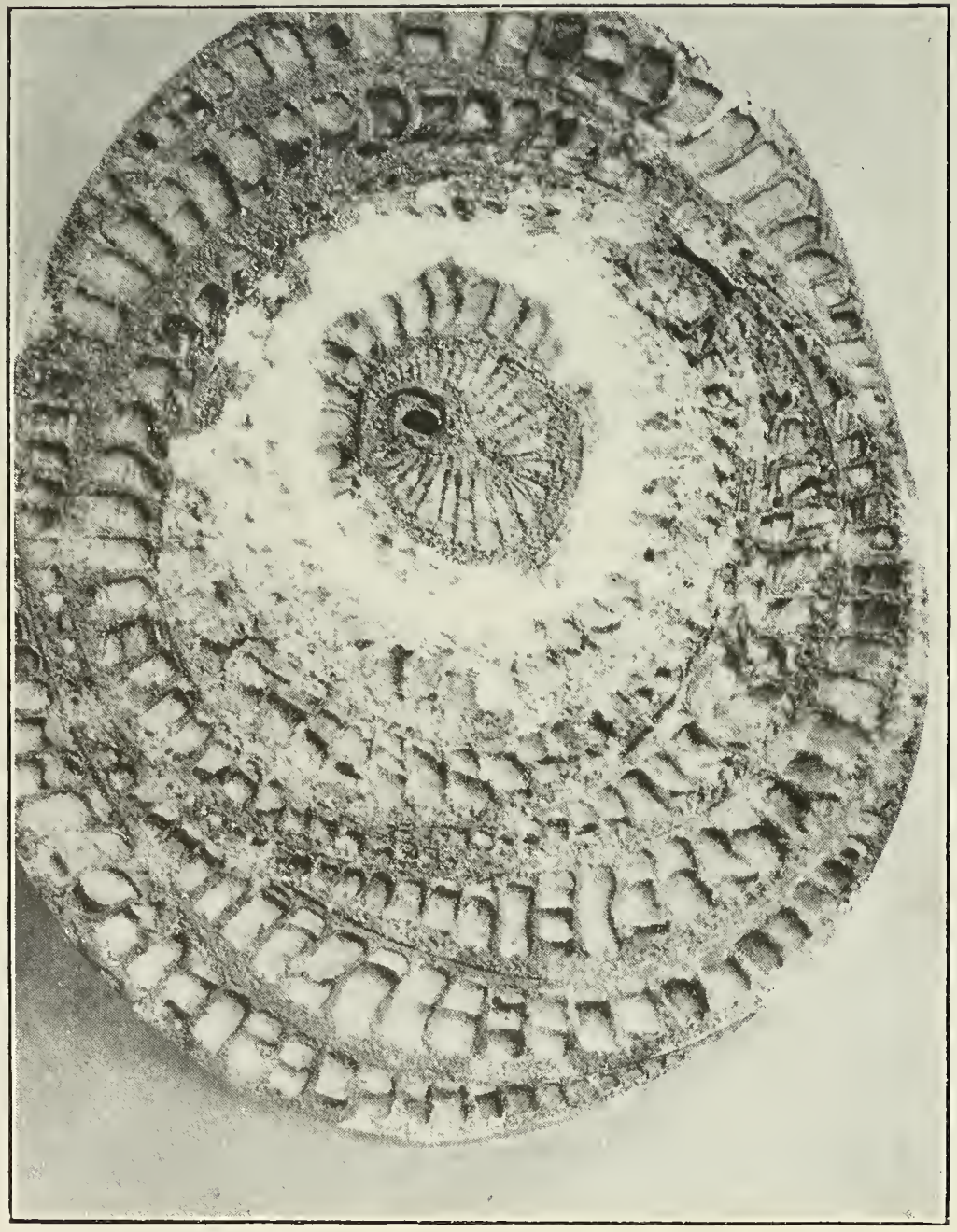

FIG. 1.—SECTION OF BANANA STEM SHOWING RING OF FUNGUS MYCELIUM.

FIG. 2.—METHOD OF STERILIZING SOIL FOR BANANA PLANTS.

FIG. 1.—BANANAS GROWN IN STERILIZED SOIL; LEFT INOCULATED WITH PURE CULTURES OF FUSARIUM, RIGHT UNINOCULATED.

FIG. 2.—EXPERIMENTAL PLATS IN BANANA DISEASE CONTROL.

eases have been discovered, and previously described fungi have been found on new hosts. Many planters have taken advantage of the opportunity to send in specimens of plants attacked by troublesome diseases. These have been identified whenever possible, and a detailed account of the treatment, if this has been worked out, has been sent to the planter.

## HERBARIUM.

The old station herbarium, which had not been added to for some time, has been taken in charge and renovated by this office and numerous additions made to it. It now contains about 1,000 numbers, representing over 100 families. A more orderly arrangement of folders in the cases has been adopted and the entire collection indexed. Most of the new collections have been identified, and some progress has been made in determining old specimens. A collection of fungi has been started and now consists of about 300 named species. This is indexed according to the plan used for the general herbarium. A host index of parasitic fungi is being maintained. Some exchanges of fungi and flowering plants have been made with the Insular Experiment Station at Rio Piedras and with the Brooklyn Botanic Garden, Brooklyn, N. Y.

## PLANT-DISEASE SURVEY.

The station has undertaken to cooperate with the Bureau of Plant Industry of the United States Department of Agriculture in the plant-disease survey which is being conducted over the mainland of the United States and its insular possessions. As few data have been accumulated as yet, it is to be expected that the benefit of the work will become more apparent after records have been kept for a number of years.

## BANANA WILT (PANAMA DISEASE).

The well-known and much-dreaded banana wilt, or Panama disease, which has been so destructive in Panama, Costa Rica, Cuba, Jamaica, and other countries in the American Tropics, has been present in the banana plantations of Porto Rico for many years. Here it has been especially injurious to the Chamaluco variety, and the appearance of diseased plants has been described by G. L. Fawcett, former plant pathologist of this station.[1] It agrees quite closely with descriptions of the disease as it occurs in other countries. The disease has been assumed to be caused by a parasitic fungus of the genus Fusarium, which has been found by several investigators to be associated with the disease. However, no formal proof of causation has come to the attention of the writer. In 1908, Erwin F. Smith [2]

[1] Porto Rico Sta. Rpt. 1915, pp. 36–41. [2] Science, n. ser., 31 (1910), No. 802, pp. 754, 755.

obtained a Fusarium from the xylem of banana plants suffering from typical Panama disease, cultures of which were used to inoculate petioles of banana plants in greenhouses in Washington, D. C. The Fusarium was found to occupy the vascular bundles 7 feet from the point of inoculation, producing the characteristic stain. Before secondary signs appeared the experiment was broken off by the removal of the plants to a new greenhouse. After remaining dry on a bench for several months, the rootstocks were planted and grew without the development of secondary signs. Dr. Smith named the organism *Fusarium cubense*. On account of the pressure of other work no further experiments were made, and no published technical description of the pathogene has appeared.

As a result of experiments performed at this station during the past year, it is now possible to furnish formal proof of the pathogenicity of the parasite. Cultures of the Fusarium were obtained easily from banana plants of the Chamaluco variety which showed typical symptoms of the wilt disease. A method of isolation found uniformly successful was to cut a cross section of the pseudostem 2 inches thick from a point about 4 feet above the surface of the ground, immerse for 10 minutes in 1 to 1,000 corrosive sublimate solution, wash five minutes in sterile distilled water, and put away in a sterile moist chamber. A luxuriant fungus growth usually appeared in about three days, springing from the band of diseased tissue found typically in plants badly attacked by this fungus (Pl. IV, fig. 1), from which, it was possible to obtain a pure culture by plating out spores. A microscopical examination of the fungus showed it to be a Fusarium. In the course of the work, this fungus has been isolated nearly 50 times. No other fungus has been isolated from banana plants affected with this disease. A Fusarium indistinguishable in its cultural characters from the one in question has frequently been isolated from the soil of affected banana plantations and adjacent fields at a depth of 4 inches.

Experiments on the etiology of the disease were begun in January 1916. Thirty cylindrical cement tiles, 3 feet in diameter and 4 feet deep, were sunk into the ground, with a rim projecting 4 inches above the surface, and filled with a mixture of river sand and clay loam. The soil in 20 of them was sterilized with steam from a specially constructed apparatus connected with a steam boiler (Pl. IV, fig. 2). The soil in 10 of the sterilized tiles was inoculated with pure cultures of the Fusarium, the other 10 being left for checks. Healthy suckers from Naguabo, Porto Rico, were planted in all of the tiles. Eight months from the time of planting all of the plants growing in inoculated soil were badly diseased and stunted, and two of them were dead. All of the check plants growing in sterilized soil were healthy and had made a remarkably vigorous growth. The difference between

the two rows is shown conspicuously in the accompanying illustration (Pl. V, fig. 1). The check plants averaged more than ten times as large (by weight) as those grown in inoculated soil. A fungus was readily reisolated from the artificially inoculated plants, which, when grown in pure culture, proved to be identical in cultural characters with the one used for inoculation. The internal structure of the check plants cut down for examination showed absolutely no sign of disease. The Fusarium causing this disease belongs to the section Elegans, provisionally erected by Wollenweber to facilitate the division of the genus Fusarium into more or less natural groups. There is no reason for believing that it is different from the fungus found by Dr. Smith in wilted banana plants from Cuba and designated by him *Fusarium cubense*.[1]

However, since no ample technical description of the organism has been published, the following description is given of it:

*Fusarium cubense* Smith. Sclerotia indigo-blue, developing from flesh-colored plectenchyma, irregular, nodule-like, 1 to 4 mm. in diameter, on potato plugs, 12 days old. Pionnotes, reduced, produced on agar slants, hyaline at first, becoming white, powdery. Sporodochia, 2 to 5 mm. in diameter, produced on agar slants in 12 to 20 days, light salmon color. Pinkish salmon color becoming tinged with blue in age produced on steamed rice grains, Cultures in confined space observed to give off a suffocating gas but no strong aromatic odor, as is the case with some Fusaria. Growth on potato plug rapid, luxuriant, dead white, aerial, at first producing only microconidia in great abundance from simple aerial conidiophores. Microconidia continuous or 1-septate, oval, average 6.65 by 3.5$\mu$. Macroconidia, from sporodochia sickle-shaped up to 95 per cent 3-septate, average 33.5 by 3.8$\mu$, range 20 to 40 by 3 to 5$\mu$ up to 5 per cent 4-septate, average 38.8 by 4.1$\mu$; occasional 1, 2, and 5 septate macroconidia. Chlamydospores mostly terminal, sometimes intercalated in hyphæ, abundant on potato plug culture seven weeks old, mostly single, sometimes paired, few short chains. Single spores average 9.45 by 7$\mu$, paired spores average 11.2 by 7.5$\mu$.

The fungus is seen to be related closely to *Fusarium vasinfectum*.

A more detailed account of the investigations carried on in connection with this disease will be given in a separate publication, together with the results of experiments in control measures, which have not yet been concluded (Pl. V, fig. 2).

In connection with the study of the life history of the above organism, some 35 fungi, many of which appear to be forms of well-known pathogenic habit, were isolated from the soil in and near banana plantations. A description of these also will appear in a separate paper.

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[1] In reply to a letter including a description of the organism, Dr. Smith has written: "Respecting the inquiries in your letter of Feb. 6, I think it is all right for you to go ahead on the assumption that the disease you have is the Cuban one. I have seen nothing in my researches on it which contradict any of the statements in your letter."